

PHYSICS-9

CHAPTER-8

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CHAPTER-8

THERMAL PROPERTIES OF MATTER

Q-1: Define and explain the following terms:

- Temperature
- Thermal contact
- Thermal equilibrium
- Heat
- Internal energy

TEMPERATURE:

“Temperature of a body is the degree of hotness or coldness of the body”

Explanation:

When we touch a body, we feel it hot or cold. The temperature of a body tells us how hot or cold a body is.

For Example:

A candle flame is hot and is said to be at high temperature. On the other hand ice is cold and is said to be at low temperature.

Remember That:

Our sense of touch is a simple way to know how much hot or cold a body is. However, this temperature sense is somewhat approximation and unreliable. Moreover, it is not always safe to touch a hot body.

Thermal Contact:

“When two bodies are at different temperatures can exchange their heat then they are said to be in thermal contact”.

Explanation:

- To store ice in summer, people wrap it with cloth or keep it in wooden box or in thermos flask. In this way, they avoid the thermal contact of ice with its hot surroundings otherwise ice will soon melt away.
- When you place a cup of hot tea or water in a room, it cools down gradually. It stops cooling as it reaches the room temperature.

Note: Temperature determines the direction of flow of heat.

Thermal Equilibrium:

“Heat flows from a hot body to a cold body until thermal equilibrium is reached”.

HEAT:

“Heat is the energy that is transferred from one body to the other in thermal contact with each other as a result of the difference of temperature between them”.

Explanation:

Take two bodies having different temperatures. Bring them in contact with each other. The temperature of the hot body falls. It loses energy. This energy enters the cold body at lower temperature. Cold body gains energy and its temperature rises. The transfer of energy continues till

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both the bodies have the same temperature. The form of energy that is transferred from a hot body to a cold body is called heat. Heat is therefore, called as the energy in transit. Once heat enters a body, it becomes its internal energy and no longer exists as heat energy.

Internal Energy:

“The sum of kinetic energy and potential energy associated with the atoms, molecules and particles of a body is called its internal energy”.

Explanation:

Internal energy of a body depends on many factors such as the mass of the body, kinetic and potential energies of molecules etc. Kinetic energy of an atom or molecule is due to its motion which depends upon the temperature. Potential energy of atoms or molecules is the stored energy due to intermolecular forces.

Q-2: What is thermometer? What are the properties of thermometric material? Discuss the construction and working of liquid in glass thermometer?

THERMOMETER:

“A device that is used to measure the temperature of a body is called thermometer”.

Thermometric Material:

Some substances have property that changes with temperature. Substances that show a change with temperature can be used as a thermometric material.

For Example:

Some substances expand on heating, some change their colours, some change their electric resistance, etc. Nearly all the substances expand on heating. Liquids also expand on heating and are suitable as thermometric materials. Common thermometers are generally made using some suitable liquid as thermometric material.

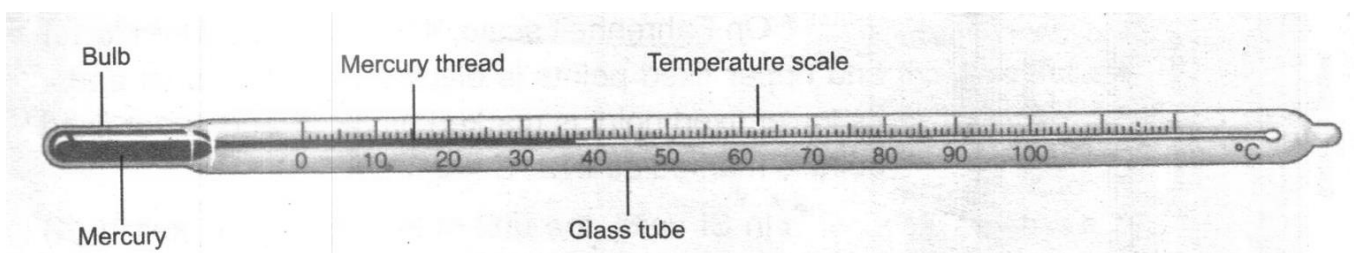
Properties of Thermometric Material:

A thermometric liquid should have the following properties.

- It should be visible.
- It should have uniform thermal expansion.
- It should have a low freezing point.
- It should have a high boiling point.
- It should not wet glass.
- It should be a good conductor of heat.
- It should have a small specific heat capacity.

Liquid in Glass Thermometer:

A liquid in glass thermometer has a bulb with a long capillary tube of uniform and fine bore. A suitable liquid is filled in the bulb. When the bulb contact a hot object, the liquid in it expands and rises in the tube. The glass stem of the thermometer is thick and acts as cylindrical lens. This makes it easy to see the liquid level in the glass tube.



Mercury as Thermometric Material:

Mercury freezes at -39°C and boils at 357°C . It has all the thermometric properties. Thus mercury is one of the most suitable thermometric material. Mercury in glass thermometers are widely used in laboratories, clinics and houses to measure temperatures in the range from -10°C to 150°C .

Lower and Upper Fixed Points:

A thermometer has a scale on its stem. This scale has two fixed points.

Lower Fixed Point:

“The lower fixed point is marked to show the position of liquid in the thermometer when it is placed in ice”.

Upper Fixed Point:

“Upper fixed point is marked to show the position of liquid in the thermometer when it is placed in steam at standard pressure above boiling water”.

Q-3: What are the scales of temperature? Write formulae to convert temperature from one scale to other temperature scale.

Scales of Temperature:

A scale is marked on the thermometer. Three scales of temperature are in common use. These are:

- Celsius scale or centigrade scale
- Fahrenheit scale
- Kelvin scale

i. Celsius Scale or Centigrade Scale:

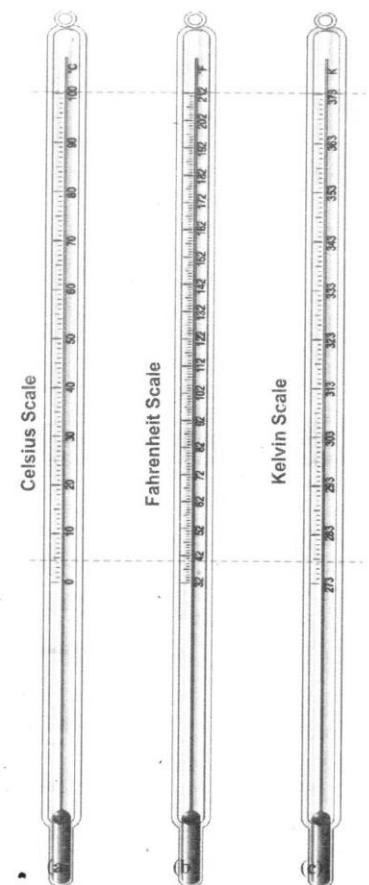
- On Celsius scale, the interval between lower and upper fixed points is divided into 100 equal parts.
- The lower fixed point is marked as 0°C .
- The upper fixed point is marked as 100°C .

ii. Fahrenheit Scale:

- On Fahrenheit scale, the interval between lower and upper fixed points is divided into 180 equal parts.
- Its lower fixed point is marked as 32°F
- The upper fixed point is marked as 212°F .

iii. Kelvin Scale:

- In SI units, the unit of temperature is kelvin (K) and its scale is called Kelvin scale of temperature.
- The interval between the lower and upper fixed points is divided into 100 equal parts.
- Thus change in 1°C is equal to a change of 1 K.
- The lower fixed point on this scale is 273 K
- The upper fixed point is 373 K.
- The zero on this scale is called the absolute zero and is equal to -273°C .



Conversion of the Temperature from One Scale to other Temperature Scale:

From Celsius to Kelvin Scale:

The temperature T_k on Kelvin scale can be obtained by adding 273 in the temperature T_c on Celsius scale. Thus

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$$T_k = T_c + 273$$

From Kelvin to Celsius Scale:

The temperature on Celsius scale can be found by subtracting 273 from the temperature in Kelvin scale. Thus

$$T_c = T_k - 273$$

From Celsius to Fahrenheit Scale:

Since 100 divisions on Celsius scale are equal to 180 divisions on Fahrenheit scale. Therefore, each division on Celsius scale is equal to 1.8 divisions on Fahrenheit scale. Moreover, 0 °C corresponds to 32 °F.

$$T_F = 1.8T_c + 32$$

Here T_F is the temperature in Fahrenheit scale and T_c is the temperature on Celsius scale.

From Fahrenheit to Celsius scale:

We can find the temperature on Celsius scale from Fahrenheit scale.

$$T_c = \frac{1}{1.8} (T_F - 32)$$

Q-4: What is specific heat capacity? Write its formula and unit.

SPECIFIC HEAT CAPACITY:

The specific heat of substance is defined as:

“Specific heat of a substance is the amount of heat required to raise the temperature of 1 kg mass of that substance through 1 K”.

Explanation:

Generally, when a body is heated, its temperature increases. Increase in the temperature of a body is found to be proportional to amount of heat absorbed by it. It has also been observed that the quantity of heat ΔQ required to raise the temperature ΔT of a body is proportional to the mass m of the body.

Mathematically:

$$\begin{aligned} \Delta Q &\propto m \Delta T \\ \text{Or} \quad \Delta Q &= c m \Delta T \end{aligned}$$

Here ΔQ is the amount of heat absorbed by the body and c is the constant of proportionality called the specific heat capacity or simply specific heat.

$$c = \frac{\Delta Q}{m \Delta T}$$

SI Unit:

In SI units, mass m is measured in kilogramme (kg), heat ΔQ is measured in joule (J) and temperature increase ΔT is taken in Kelvin (K). Hence, SI unit of specific heat capacity is $\text{Jkg}^{-1}\text{K}^{-1}$.

Q-5: What is heat capacity? Write its formula.

HEAT CAPACITY:

We can define heat capacity of a body as:

“Heat capacity of a body is the quantity of thermal energy absorbed by it for one kelvin increase in its temperature”.

Mathematically:

If the temperature of a body increases through ΔT on adding ΔQ amount of heat, then its heat capacity will be

$$\text{Heat capacity} = \frac{\Delta Q}{\Delta T}$$

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Putting the value of $\Delta Q = c m \Delta T$ we get

$$= \frac{m c \Delta T}{\Delta T}$$

$$\text{Heat capacity} = mc$$

Equation shows that heat capacity of a body is equal to the product of its mass of the body and its specific heat capacity.

For Example:

Heat capacity of 5 kg of water is $5 \text{ kg} \times 4200 \text{ Jkg}^{-1}\text{K}^{-1} = 21000 \text{ JK}^{-1}$. That is 5 kg of water needs 21000 joules of heat for every 1 K rise in its temperature. Thus, larger is the quantity of a substance, larger will be its heat capacity.

Q-6: Briefly explain the importance of large specific heat capacity of water?

IMPORTANCE OF LARGE SPECIFIC HEAT CAPACITY OF WATER:

Moderate Temperature Near Sea Shore:

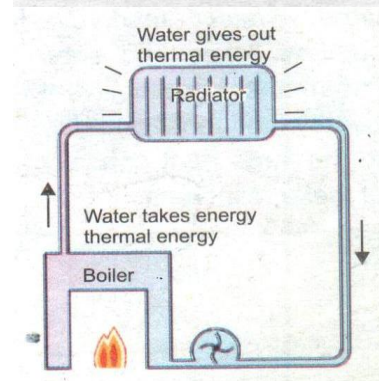
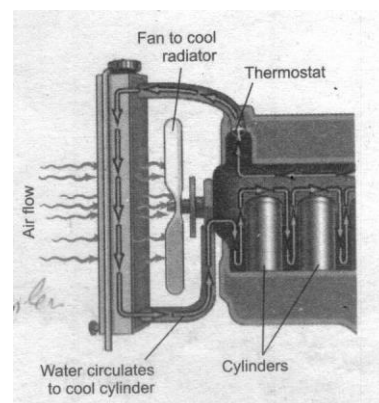
Specific heat of water is $4200 \text{ Jkg}^{-1}\text{K}^{-1}$ and that of dry soil is about $810 \text{ Jkg}^{-1}\text{K}^{-1}$. As a result the temperature of soil would increase five times more than the same mass of water by the same amount of heat. Thus, the temperature of land rises and falls more rapidly than that of the sea. Hence, the temperature variations from summer to winter are much smaller at places near the sea than land far away from the sea.

Storing Thermal Energy:

Water has a large specific heat capacity. For this reason, it is very useful in storing and carrying thermal energy due to its high specific heat capacity.

Use of Water in Cooling System of Automobiles:

The cooling system of automobiles uses water to carry away unwanted thermal energy, in an automobile, large amount of heat is produced by its engine due to which its temperature goes on increasing. The engine would cease unless it is not cooled down. Water circulating around the engine maintains its temperature. Water absorbs unwanted thermal energy of the engine and dissipates heat through its radiator.



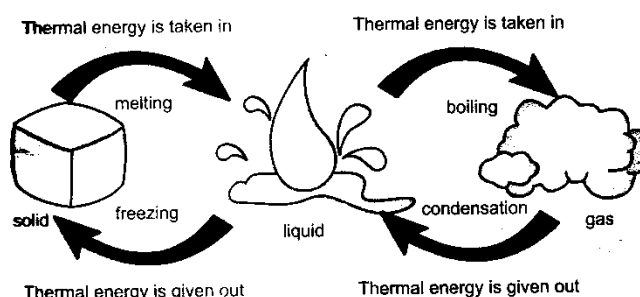
Use of Water in Central Heating Systems:

In central heating systems, hot water is used to carry thermal energy through pipes from boiler to radiator. These radiators are fixed inside the house at suitable places.

Q-7: How matter can be changed from one state to another. Explain with graph.

CHANGE OF STATE:

Matter can be changed from one state to another. For such a change to occur, thermal energy is added to or removed from a substance.

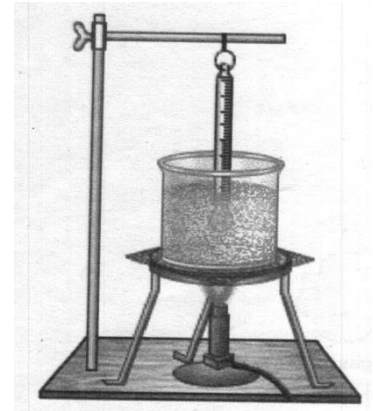


Latent Heat:

“The amount of heat required to change the state of matter at constant temperature is called latent heat”.

Activity:

Take a beaker and place it over a stand. Put small pieces of ice in the beaker and suspend a thermometer in the beaker to measure the temperature of ice. Now place a burner under the beaker. The ice will start melting. The temperature of the mixture containing ice and water will not increase above 0 °C until all ice melts and we get water at 0 °C. If this water at 0 °C is further heated, its temperature begins to increase above 0 °C.



Explanation of Graph:

Part AB:

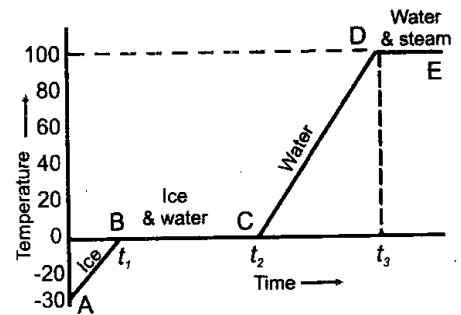
On this portion of the curve, the temperature of ice increases from –30 °C to 0 °C.

Part BC:

When the temperature of ice reaches 0 °C, the ice water mixture remains at this temperature until all the ice melts.

Part CD:

The temperature of the substance gradually increases from 0 °C to 100 °C. The amount of energy so added is used up in increasing the temperature of water.



Part DE:

At 100 °C water begins to boil and changes into steam. The temperature remains 100 °C until all the water changes into steam.

Q-8: Define and explain latent heat of fusion? Write its formula.

LATENT HEAT OF FUSION:

“Heat energy required to change unit mass of a substance from solid to liquid state at its melting point without change in its temperature is called its latent heat of fusion”.

Note: It is denoted by H_f .

Mathematically:

$$H_f = \frac{\Delta Q_f}{m}$$

Or

$$\Delta Q_f = m H_f$$

Latent Heat of Ice:

Ice changes at 0 °C into water. Latent heat of fusion of ice is $3.36 \times 10^5 \text{ Jkg}^{-1}$, i.e. 3.36×10^5 joule heat is required to melt 1 kg of ice into water at 0 °C.

Melting or Fusion:

“When a substance is changed from solid to liquid state by adding heat, the process is called melting or fusion”.

Melting Point or Fusion Point:

“The temperature at which a solid starts melting is called its fusion point or melting point”.

Freezing Point:

“When a liquid is cooled, it changes into solid state. The temperature at which a substance changes from liquid to solid state is called its freezing point”.

Note: Different substances have different melting points. However, the freezing point of a substance is the same as its melting point.

Q-9: Define and explain latent heat of vaporization? Write its formula.

LATENT HEAT OF VAPORIZATION:
“The quantity of heat that changes unit mass of a liquid completely into gas at its boiling point without any change in its temperature is called its latent heat of vaporization”.

Note: It is denoted by H_v

Mathematically:

Or

$$H_v = \frac{\Delta Q_v}{m}$$
$$\Delta Q_v = m H_v$$

Latent Heat of Water:
When water is heated, it boils at 100 °C under standard pressure. Its temperature remains 100 °C until it is changed completely into steam. Its latent heat of vaporization is $2.26 \times 10^6 \text{ Jkg}^{-1}$. That is, one kilogramme water requires 2.26×10^6 joule heat to change it completely into gas (steam) at its boiling point.

Explanation:
When heat is given to a liquid at its boiling point, its temperature remains constant. The heat energy given to a liquid at its boiling point is used up in changing its state from liquid to gas without any increase in its temperature.

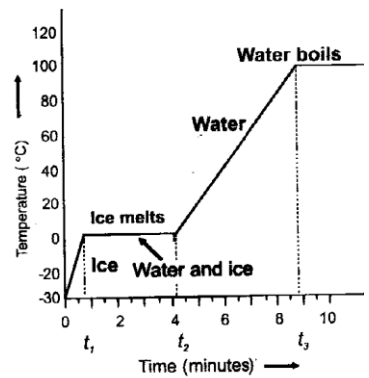
Table:
The value of melting point, boiling point, latent heat of fusion and vaporization of some of the substances is given in Table.

Substance	Melting Point (°C)	Boiling Point (°C)	Heat of Fusion (kJkg ⁻¹)	Heat of vaporization (kJkg ⁻¹)
Aluminum	660	2450	39.7	10500
Copper	1083	2595	205.0	4810
Gold	1063	2660	64.0	1580
Helium	-270	-269	5.2	21
Lead	327	1750	23.0	858
Mercury	-39	357	11.7	270
Nitrogen	-210	-196	25.5	200
Oxygen	-219	-183	13.8	210
Water	0	100	336.0	2260

Q-10: Calculate the latent heat of fusion of ice by a simple experiment?

- Experiment:**
- Take a beaker and place it over a stand. Put small pieces of ice in the beaker and suspend a thermometer in the beaker to measure the temperature.
 - Place a burner under the beaker. The ice will start melting. The temperature of the mixture containing ice and water will not increase above 0 °C until all the ice melts.
 - Note the time which the ice takes to melt completely into water at 0 °C.

- Continue heating the water at 0°C in the beaker. Its temperature will begin to increase. Not the time which the water in the beaker takes to reach its boiling point at 100 °C from 0 °C.
- Draw a temperature–time graph such as shown in figure.



Calculation of Latent of Fusion:

Calculate the latent heat of fusion of ice from the data as follows:

Let

Mass of ice

$$= m$$

Finding the time form the graph

Time take by ice to melt completely at 0°C

$$= t_f = t_2 - t_1 = 3.6 \text{ min.}$$

Time taken by water to heat from 0 °C to 100 °C

$$= t_o = t_3 - t_2 = 4.6 \text{ min.}$$

Specific heat of water

$$= c = 4200 \text{ Jkg}^{-1}\text{K}^{-1}$$

Increase in the temperature of water

$$= \Delta T = 100^\circ\text{C} = 100 \text{ K}$$

Heat required by water from 0 °C to 100 °C

$$\begin{aligned} &= \Delta Q = m c \Delta T \\ &= m \times 4200 \text{ Jkg}^{-1}\text{K}^{-1} \times 100 \text{ K} \\ &= m \times 420\,000 \text{ Jkg}^{-1} \\ &= \Delta Q = m \times 4.2 \times 10^5 \text{ Jkg}^{-1} \dots\dots\dots (1) \end{aligned}$$

Heat ΔQ is supplied to water in the time t_o to raise its temperature from 0 °C to 100 °C. Hence, the rate of absorbing heat by water in the beaker is given by

$$\text{Rate of absorbing heat} = \frac{\Delta Q}{t_o}$$

$$\begin{aligned} \text{Heat absorbed in time } t_f &= \Delta Q_f = \frac{\Delta Q}{t_o} \times t_f \\ &= \Delta Q \times \frac{t_f}{t_o} \dots\dots\dots (2) \end{aligned}$$

$$\text{Since} \quad \Delta Q_f = m \times H_f \dots\dots\dots (3)$$

Comparing (2) and (3), we get

$$m \times H_f = \Delta Q \times \frac{t_f}{t_o}$$

By using (1) in above

$$\begin{aligned} m \times H_f &= m \times 4.2 \times 10^5 \text{ Jkg}^{-1} \times \frac{t_f}{t_o} \\ H_f &= 4.2 \times 10^5 \text{ Jkg}^{-1} \times \frac{t_f}{t_o} \end{aligned}$$

The value of t_f and t_o can be found from the graph.

Put the values in the above equation to get.

$$\begin{aligned} H_f &= 4.2 \times 10^5 \text{ Jkg}^{-1} \times \frac{3.6 \text{ min.}}{4.6 \text{ min.}} \\ &= 3.29 \times 10^5 \text{ Jkg}^{-1} \end{aligned}$$

Conclusion:

The latent heat of fusion of ice found by the above experiment is $3.29 \times 10^5 \text{ Jkg}^{-1}$ while its actual value is $3.36 \times 10^5 \text{ Jkg}^{-1}$.

Q-11: Calculate the latent heat of vaporization of water by a simple experiment?

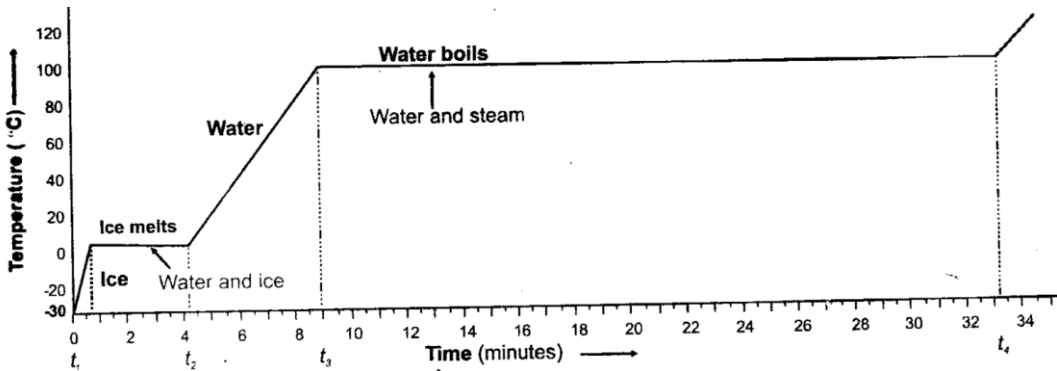
Experiment:

- Take a beaker and place it over a stand. Put small pieces of ice in the beaker and suspend a thermometer in the beaker to measure the temperature.
- Place a burner under the beaker. The ice will start melting. The temperature of the mixture containing ice and water will not increase above 0 °C until all the ice melts.
- Note the time which the ice takes to melt completely into water at 0 °C.
- Continue heating the water at 0°C in the beaker. Its temperature will begin to increase. Not the

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time which the water in the beaker takes to reach its boiling point at 100 °C from 0 °C.

- Continue heating water till all the water changes into steam. Not the time which the water in the beaker takes to change completely into steam at its boiling point 100°C.
- Draw a temperature–time graph such as shown in figure.



Calculation of Latent of Vaporization:

Calculate the latent heat of vaporization of water from the data as follows:

Let

Mass of ice = m

Finding the time form the graph

Time taken by water to heat from 0 °C to 100 °C = $t_0 = t_3 - t_2 = 4.6 \text{ min.}$

Time take by water to change into steam 100 °C = $t_v = t_4 - t_3 = 24.4 \text{ min.}$

Specific heat of water = c = 4200 Jkg⁻¹K⁻¹

Increase in the temperature of water = $\Delta T = 100^\circ\text{C} = 100 \text{ K}$

Heat required by water from 0 °C to 100 °C = $\Delta Q = m c \Delta T$
 $= m \times 4200 \text{ Jkg}^{-1}\text{K}^{-1} \times 100 \text{ K}$
 $= m \times 420\,000 \text{ Jkg}^{-1}$
 $= \Delta Q = m \times 4.2 \times 10^5 \text{ Jkg}^{-1} \dots\dots\dots (1)$

Heat ΔQ is supplied to water in the time t_0 to raise its temperature from 0 °C to 100 °C. Hence, the rate of absorbing heat by water in the beaker is given by

Rate of absorbing heat

= $\frac{\Delta Q}{t_0}$

Heat absorbed in time t_v

= $\Delta Q_v = \frac{\Delta Q}{t_0} \times t_v$

= $\Delta Q \times \frac{t_v}{t_0} \dots\dots\dots (2)$

Since

= $\Delta Q_v = m \times H_v \dots\dots\dots (3)$

Comparing (2) and (3), we get

$m \times H_v = \Delta Q \times \frac{t_v}{t_0}$

By using (1) in above

$m \times H_v = m \times 4.2 \times 10^5 \text{ Jkg}^{-1} \times \frac{t_v}{t_0}$

$H_v = 4.2 \times 10^5 \text{ Jkg}^{-1} \times \frac{t_v}{t_0}$

The value of t_v and t_0 can be found from the graph.

Put the values in the above equation to get.

$H_v = 4.2 \times 10^5 \text{ Jkg}^{-1} \times \frac{24.4 \text{ min.}}{4.6 \text{ min.}}$

$= 2.23 \times 10^6 \text{ Jkg}^{-1}$

Conclusion:

The latent heat of vaporization of water found by the above experiment is $2.23 \times 10^6 \text{ Jkg}^{-1}$ while its actual value is $2.26 \times 10^6 \text{ Jkg}^{-1}$.

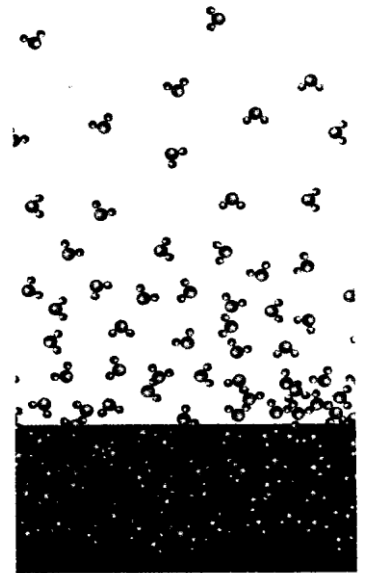
Q-12: Define and explain evaporation? What is the importance of evaporation? What are the factors upon which evaporation depends?

EVAPORATION:

“Evaporation is the changing of liquid into vapours (gaseous state) from the surface of the liquid without heating it.”

Explanation:

Take some water in a dish. The water in the dish will disappear after sometime. It is because the molecules of water are in constant motion and possess kinetic energy. Fast moving molecules escape out from the surface of water and goes into the atmosphere. This is called evaporation.



Difference between Evaporation and Vaporization:

Unlike boiling, evaporation takes place at all temperatures but only from the surface of liquid. The process of vaporization takes place at a certain fixed temperature which is the boiling point of that liquid. At boiling point, a liquid is changing into vapours not only from the surface also within the liquid. These vapours come out of the boiling liquid as bubbles which breakdown on reaching the surface.

Importance of Evaporation:

Evaporation plays an important role in our daily life. Wet clothes dry up rapidly when spread. During evaporation fast moving molecules escape out from the surface of liquid. Molecules that have lower kinetic energies are left behind. This lowers the average kinetic energy of the liquid molecules and the temperature of the liquid. Since temperature of a substance depends on the average kinetic energy of its molecules. Evaporation of perspiration helps to cool our bodies.

Factors Affecting Evaporation:

Evaporation takes place at all temperature from the surface of liquid. The rate of evaporation is affected by various factors.

i. Temperature:

Wet clothes dry up more quickly in summer than in winter. At higher temperature, more molecules of a liquid are moving with high velocities. Thus, more molecules escape from its surface. Thus, evaporation is faster at high temperature than at low temperature.

ii. Surface Area:

Water evaporates faster when spread over large area. Larger is the surface area of a liquid, greater number of molecules has the chance to escape from its surface.

iii. Wind:

Wind blowing over the surface of a liquid sweeps away the liquid molecules that have just escaped out. This increases the chance for more liquid molecules to escape out.

iv. Nature of the Liquid:

Liquids differ in the rate at which they evaporate. Spread a few drops of ether or spirit on your palm. You feel cold.

Q-13: Define and explain thermal expansion.

THERMAL EXPANSION:

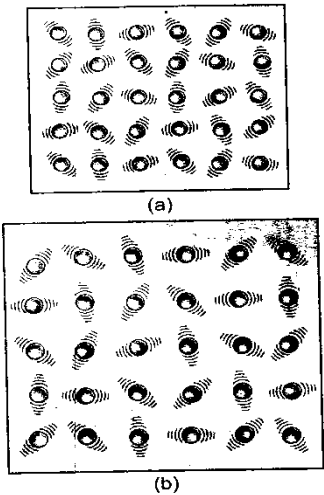
“Expansion due to heating is called thermal expansion”.

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Explanation:

Most of the substances solids, liquids and gases expand on heating and contract on cooling. Their thermal expansion and contractions are usually small and are not noticeable. However, these expansions and contractions are important in our daily life.

The kinetic energy of the molecules of an object depends on its temperature. The molecules of solid vibrate with larger amplitude at high temperature than at low temperature. Thus, on heating, the amplitude of vibration of the atoms or molecules of an object increases. They push one another farther away as the amplitude of vibration increases. Thermal expansion results an increase in length, breadth and thickness of a substance.



Q-14: What is linear thermal expansion? On what factors it depends? Explain.

LINEAR THERMAL EXPANSION IN SOLIDS:

“The length of solid changes with the change in temperature, it is called linear thermal expansion”.

Explanation

Consider a metal rod of length L_0 at certain temperature T_0 . Let its length on heating to a temperature T becomes L . Thus

Increase in length of the rod

=

ΔL

=

$L - L_0$

Increase in temperature

=

ΔT

=

$T - T_0$

Dependence of Linear Thermal Expansion:

It is found that change in length ΔL of a solid is directly proportional to its original length L_0 and the change in temperature ΔT . i.e.

ΔL

$\propto$

$L_0 \Delta T$

Or

ΔL

$=$

$\alpha L_0 \Delta T$

..... (1)

Or

$L - L_0$

$=$

$\alpha L_0 \Delta T$

Or

L

$=$

$L_0 + \alpha L_0 \Delta T$

L

$=$

$L_0 (1 + \alpha \Delta T)$

..... (2)

Where α is called the coefficient of linear thermal expansion of the substance.

From equation (1), we get

α

$=$

$\frac{\Delta L}{L_0 \Delta T}$

Coefficient of Linear Thermal Expansion:

We can define

“The coefficient of linear thermal expansion α of a substance as the fractional increase in its length per Kelvin rise in temperature”.

Q-15: What is volume thermal expansion? On what factors it depends? Explain.

VOLUME THERMAL EXPANSION:

“The volume of a solid changes with the change in temperature, it is called volume thermal expansion or cubical thermal expansion”.

Explanation:

Consider a solid of initial volume V_0 at certain temperature T_0 . On heating the solid to a temperature T , let its volume becomes V then,

Change in the volume of a solid

=

ΔV

=

$V - V_0$

Change in temperature

=

ΔT

=

$T - T_0$

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Dependence of Volume Thermal Expansion:

It is found that like linear expansion, the change in volume ΔV is found to be proportional to its original volume V_0 and change in temperature ΔT . Thus

$$\Delta V \propto V_0 \Delta T$$

$$\text{Or } \Delta V = \beta V_0 \Delta T \quad \dots\dots\dots (1)$$

$$\text{Or } V - V_0 = \beta V_0 \Delta T$$

$$\text{Or } V = V_0 + \beta V_0 \Delta T$$

$$V = V_0 (1 + \beta \Delta T) \quad \dots\dots\dots (2)$$

Where β is coefficient of volume thermal expansion of the substance.

From equation (1), we get

$$\beta = \frac{\Delta V}{V_0 \Delta T}$$

Coefficient of Volume Thermal Expansion:

We can define

“The coefficient of volume thermal expansion β of a substance as the fractional increase in its volume per Kelvin rise in temperature”.

Relation between α and β :

The coefficients of linear expansion and volume expansion are related by the equation:

$$\beta = 3\alpha$$

Q-16: What are the consequences and application of thermal expansion?

CONSEQUENCES OF THERMAL EXPANSION:

The expansion of solids may damage the bridges, railway tracks and road as they are constantly subjected to temperature changes. So provision is made during construction for expansion and contraction with temperature.

For Example:

- Railway tracks buckled on a hot summer day due to expansion if gaps are not left between sections.
- Bridges made of steel girders also expand during the day and contract during night. They will bend if their ends are fixed. To allow thermal expansion, one end is fixed while the other end of the girder rests on rollers in the gap left for expansion.
- Overhead transmission lines are also given a certain amount of sag so they can contract in winter without snapping.

Applications of Thermal Expansion:

Thermal expansion is used in our daily life.

For Example:

- In thermometers, thermal expansion is used in temperature measurements.
- To open the cap of a bottle that is tight enough, immerse it in hot water for a minute or so. Metal cap expands and becomes loose. It would now be easy to turn it to open.
- To join steel plates tightly together, red hot rivets are forced through holes in the plates as on cooling, the rivets contract and bring the plates tightly gripped.



Figure 8.15: Gaps are left in railway tracks to compensate thermal expansion during hot season.

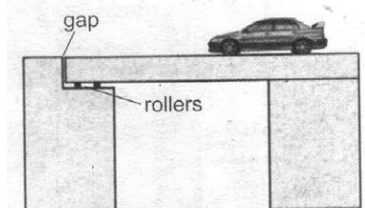


Figure 8.16: Bridges with rollers below one of their ends allow movements due to expansion and contraction.

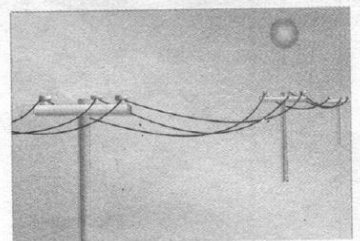


Figure 8.17: Wires on electric poles are given some sag to prevent breaking in winter.

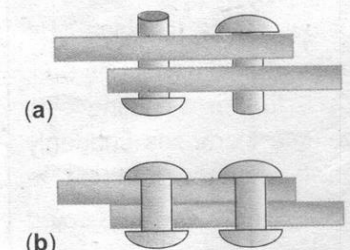


Figure 8.18 (a) Hot rivets inserted (b) after hammering, rivets are cold down.

- iv. Iron rims are fixed on wooden wheel of carts. Iron rims are heated. Thermal expansion allows them to slip over the wooden wheel. Water is poured on it to cool. The rim contracts and becomes tight over the wheel.

Q-17: Write the construction and working of bimetal strip?

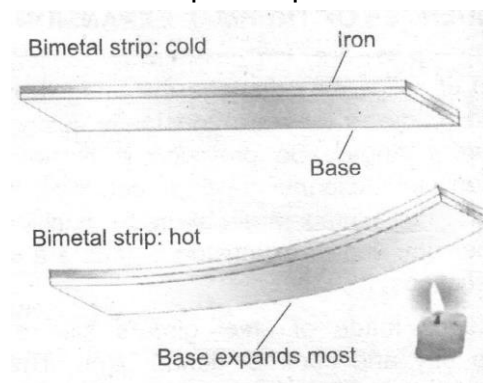
BIMETAL STRIP:

A bimetal strip consists of two thin strips of different metals such as brass and iron joined together. On heating the strip, brass expands more than iron. This unequal expansion causes bending of the strip.

Uses of Bimetal Strip:

Bimetal strips are used for various purposes.

- Bimetal thermometers are used to measure temperature especially in furnaces and ovens.
- Bimetal strips are also used in thermostats. Bimetal thermostat switch is used to control the temperature of heater coil in an electric iron.



Q-18: Define and explain thermal expansion of liquid? How thermal expansion of liquid can be determined? Explain with experiment.

THERMAL EXPANSION OF LIQUIDS:

“Expansion of a liquid upon heating is called the thermal expansion of the liquids”.

Explanation:

The molecules of liquids are free to move in all directions within the liquid. On heating a liquid, the average amplitude of vibration of its molecules increases. The molecules push each other and need more space to occupy. This accounts for the expansion of liquid when heated.

Liquid Expands More Than Solid:

The thermal expansion in liquids is greater than solids due to the weak forces between their molecules. Therefore, the coefficient of volume expansion of liquids is greater than solids.

Shape of Liquids:

Liquids have no definite shape of their own. A liquid always attains shape of the container in which it is poured. Therefore, when a liquid is heated, both liquid and the container undergo a change in their volume.

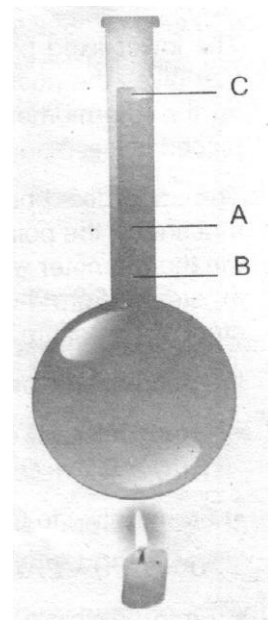
Types of Thermal Volume Expansion for Liquid:

There are two types of thermal volume expansion for liquid.

- Apparent volume expansion
- Real volume expansion

Method to Determine the Thermal Expansion in Liquids:

- Take a long necked flask.
- Fill it with some coloured liquid up to the mark A on its neck.
- Now start heating the flask from bottom. The liquid level first falls to B and then rises to C.
- The heat first reaches the flask which expands and its volume increases. As a result liquid descends in the flask and its level falls to B.
- After sometime, the liquid begins to rise above B on getting hot.
- At certain temperature it reaches at C.
- The rise in level from A to C is due to the apparent expansion of the liquid.



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viii. Actual expansion of the liquid is greater than that due to the expansion because of the expansion of the glass flask.

ix. Thus real expansion of the liquid is equal to the volume difference between A and C in addition to the volume expansion of the flask. Hence

Real expansion = Apparent expansion of the liquid + Expansion of the flask
Or BC = AC + AB

The expansion of the volume of a liquid taking into consideration the expansion of the container also, is called the real volume expansion of the liquid.

The Real Rate of Volume Expansion:

“The real rate of volume expansion β_r of a liquid is the actual change in the unit volume of a liquid for 1 K or $^{\circ}\text{C}$ rise in its temperature”.

Remember that:

The real rate of volume expansion β_r is always greater than the apparent rate of volume expansion β_a by an amount equal to the rate of volume expansion the container β_g . Thus,

$\beta_r = \beta_a + \beta_g$

It should be noted that different liquids have different coefficients of volume expansion.

DO YOU KNOW

1. How the crocus flower is a natural thermometer?

Ans: The crocus flower is a natural thermometer. It opens when the temperature is precisely 23°C and closes when the temperature drops.

2. Write temperature of some substances?

Ans:

Sun’s core	15 000 000 $^{\circ}\text{C}$
Sun’s surface	6000 $^{\circ}\text{C}$
Electric lamp	2500 $^{\circ}\text{C}$
Gas lamp	1580 $^{\circ}\text{C}$
Boiling water	100 $^{\circ}\text{C}$
Human body	37 $^{\circ}\text{C}$
Freezing water	0 $^{\circ}\text{C}$
Ice in freezer	-18°C
Liquid oxygen	-180°C

3. What do you know about clinical thermometers?

Ans: A clinical thermometer is used to measure the temperature of human body. It has a narrow range from 35°C to 42°C . It has a construction that prevents the mercury to return. Thus, its reading does not change until reset.

4. Why climate of land near large water reservoirs remains moderate?

Ans: The presence of large water reservoirs such as lakes and seas keep the climates of nearby land moderate due to the large heat capacity of these reservoirs.

5. Which gas is used in refrigerators and what are its effects on ozone layer?

Ans: Cooling is produced in refrigerators by evaporation of a liquefied gas. This produce cooling effect. Freon, a CFC, was used as refrigerant gas.

But its use has been forbidden when it was known that CFC is the cause of ozone depletion in the upper atmosphere which results increase in amount of UV rays from the Sun. The rays are harmful to all living matter. Freon gas is now replaced by ammonia and other substances which are not harmful to environment.

6. What is anomalous expansion of water?

Ans: Water on cooling below 4 °C begins to expand until it reaches 0 °C. On further cooling its volume increases suddenly as it changes into ice at 0 °C. It contracts i.e. its volume decreases like solids. This unusual expansion of water is called the anomalous expansion of water.

7. Write specific heat capacity of some common substances.

Ans:

Specific Heat of Some Common Substances	
Substance	Specific heat Jkg ⁻¹ K ⁻¹
Alcohol	2500.0
Aluminum	903.0
Bricks	900.0
Carbon	121.0
Clay	920.0
Copper	387.0
Ether	2010.0
Glass	840.0
Gold	128.0
Granite	790.0
Ice	2100.0
Iron	470.0
Lead	128.0
Mercury	138.6
Sand	835.0
Silver	235.0
Soil (dry)	810.0
Steam	2016.0
Tungsten	134.8
Turpentine	1760.3
Water	4200.0
Zinc	385.0

8. Write coefficient of linear thermal expansion α of some common solids?

Ans:

Substance	α (K ⁻¹)
Aluminum	2.4 × 10 ⁻⁵
Brass	1.9 × 10 ⁻⁵
Copper	1.7 × 10 ⁻⁵
Steel	1.2 × 10 ⁻⁵
Silver	1.93 × 10 ⁻⁵
Gold	1.3 × 10 ⁻⁵
Platinum	8.6 × 10 ⁻⁵
Tungsten	0.4 × 10 ⁻⁵
Glass (Pyrex)	0.4 × 10 ⁻⁵
Glass (Ordinary)	0.9 × 10 ⁻⁵
Concrete	1.2 × 10 ⁻⁵

3. How evaporation differs from vaporization?

Ans: Unlike boiling, evaporation takes place at all temperatures but only from the surface of liquid. The process of vaporization takes place at a certain fixed temperature which is the boiling point of that liquid. At boiling point, a liquid is changing into vapours not only from the surface also within the liquid. These vapours come out of the boiling liquid as bubbles which breakdown on reaching the surface.

MULTIPLE CHOICE EXERCISE

Q-8.1: Multiple Choice Questions:

- i. Water freezes at
- a) 0 °F b) 32 °F
c) -273 K d) 0 K
- ii. Normal human body temperature is
- a) 15 °C b) 37 °C
c) 37 °F d) 98.6 °C
- iii. Mercury is used as thermometric material because it has
- a) uniform thermal expansion b) low freezing point
c) small heat capacity d) all of the above
- iv. Which of the following material has large specific heat?
- a) copper b) ice
c) water d) mercury
- v. Which of the following material has large value of temperature coefficient of linear expansion?
- a) aluminum b) gold
c) brass d) steel
- vi. What will be the value of β for a solid for which α has a value of $2 \times 10^{-5} \text{ K}^{-1}$?
- a) $2 \times 10^{-5} \text{ K}^{-1}$ b) $6 \times 10^{-5} \text{ K}^{-1}$
c) $8 \times 10^{-15} \text{ K}^{-1}$ d) $8 \times 10^{-5} \text{ K}^{-1}$
- vii. A large water reservoir keeps the temperature of nearby land moderate due to
- a) low temperature of water b) low specific heat of water
c) less absorption of water d) large specific heat of water
- viii. Which of the following affects evaporation?
- a) temperature b) surface area of the liquid
c) wind d) all of the above

CHAPTER-8			9 th PHYSICS MCQS ANSWERS				
i	ii	iii	iv	v	vi	vii	viii
b	b	d	c	a	b	d	d

REMAINING EXERCISE

Q-8.2: Why does heat flow from hot body to cold body?

Ans: Heat flows due to difference of temperature from higher temperature to lower temperature. As the temperature of the hot body is more than the cold body, therefore heat flows from hot body to cold body.

نظریاتی اختلافات کو تلخی اور تشدد میں نہیں ڈھالنا چاہیے۔

Q-8.3: Define the terms heat and temperature.

Ans: See Notes Q-1

Q-8.4: What is meant by internal energy of a body?

Ans: See Notes Q-1

Q-8.5: How does heating effect the motion of the molecules of a gas?

Ans: The molecules of a gas have random motion move with high velocities. If a gas is heated, its temperature rises and its molecules will move vigorously with very high velocities. The molecules exert more pressure on the walls of the container.

Q-8.6: What is a thermometer? Why mercury is preferred as a thermometric substance?

Ans: See Notes Q-2

Q-8.7: Explain the volumetric thermal expansion?

Ans: See Notes Q-15

Q-8.8: Define specific heat. How would you find the specific heat of a solid?

Ans: See Notes Q-4

Q-8.9: Define and explain latent heat of fusion?

Ans: See Notes Q-8

Q-8.10: Define latent heat of vaporization.

Ans: See Notes Q-9

Q-8.11: What is meant by evaporation? On what factors the evaporation of a liquid depends? Explain how cooling is produced by evaporation.

Ans: See Notes Q-12

FORMULAE USE IN CHAPTER-8

Conversion of Temperature Scales:

1. From Celsius to Kelvin Scale:

$$T_K = T_C + 273$$

2. From Kelvin to Celsius Scale:

$$T_C = T_K - 273$$

3. From Celsius to Fahrenheit Scale:

$$T_F = 1.8T_C + 32$$

4. From Fahrenheit to Celsius Scale:

$$T_C = \frac{1}{1.8} (T_F - 32)$$

5. Specific Heat Capacity

$$\Delta Q = mc\Delta T$$

6. Heat Capacity

$$\text{Heat capacity} = mc$$

7. Latent Heat of Fusion

$$\Delta Q_f = mH_f$$

8. Latent Heat of Vaporization

$$\Delta Q_v = mH_v$$

9. $L = L_0(1 + \alpha\Delta T)$ (Linear Expansion)

10. $V = V_0(1 + \beta\Delta T)$ (Volume Expansion)

11. $\beta = 3\alpha$

12. $\beta_r = \beta_a + \beta_g$

EXAMPLES

Example 8.1: What will be the temperature on Kelvin scale of temperature when it is 20 °C on Celsius scale?

Sol: Temperature on Celsius scale = $T_C = 20^\circ\text{C}$
Temperature on Kelvin scale = $T_K = ?$

Now

$$\begin{aligned} T_K &= T_C + 273 \\ &= 20 + 273 \\ T_K &= 293 \text{ K} \end{aligned}$$

Example 8.2: Change 300 K on Kelvin scale into Celsius scale of temperature.

Sol: Temperature on Kelvin scale = T_K = 300 K
Temperature on Celsius scale = T_C = ?

Now

$$\begin{aligned} T_C &= T_K - 273 \\ &= 300 - 273 \\ T_C &= 27^\circ\text{C} \end{aligned}$$

Example 8.3: Convert 50 °C on Celsius scale into Fahrenheit temperature scale.

Sol: Temperature on Celsius scale = $T_C = 50^\circ\text{C}$
Temperature on Fahrenheit scale = $T_F = ?$

Now

$$\begin{aligned} T_F &= 1.8T_C + 32 \\ &= 1.8(50) + 32 \\ &= 90 + 32 \\ T_F &= 122^\circ\text{F} \end{aligned}$$

Example 8.4: Convert 100 °F into the temperature on Celsius scale.

Sol: Temperature on Fahrenheit scale = $T_F = 100^\circ\text{F}$
Temperature on Celsius scale = $T_C = ?$

Now

$$\begin{aligned} T_C &= \frac{1}{1.8} (T_F - 32) \\ &= \frac{1}{1.8} (100 - 32) \\ &= \frac{1}{1.8} (68) \\ T_C &= 37.8^\circ\text{C} \end{aligned}$$

Example 8.5: A container has 2.5 liters of water at 20 °C. How much heat is required to boil the water?

Sol:

Volume of water	= V	= 2.5 liter	
Mass of water	= m	= 2.5 kg	As (1 lit = 1 kg)
Specific heat of water	= c	= 4200 Jkg ⁻¹ K ⁻¹	
Initial temperature	= T ₁	= 20 °C = 20 + 273 = 293 K	
Final temperature	= T ₂	= 100 °C = 100 + 273 = 373 K	
Change in temperature	= ΔT	= 373 – 293 = 80 K	
Amount of heat	= ΔQ	= ?	
Now			

$$\begin{aligned}\Delta Q &= mc\Delta T \\ &= 2.5 \times 4200 \times 80 \\ &= 840\,000 \text{ J} \\ &= 840 \text{ kJ}\end{aligned}$$

تمام برائیاں نفس کی تباہی سے پیدا ہوتی ہیں۔ (حضرت ابو بکر دراقؓ)

Example 8.6: A brass rod is 1m long at 0 °C. Find its length at 30°C. (Coefficient of linear expansion of brass is $1.9 \times 10^{-5} \text{ K}^{-1}$)

Sol: Initial length = $L_0 = 1 \text{ m}$
 Initial temperature = $T_0 = 0^\circ\text{C} = 0 + 273 = 273 \text{ K}$
 Final temperature = $T = 30^\circ\text{C} = 30 + 273 = 303 \text{ K}$
 Change in temperature = $\Delta T = 303 - 273 = 30 \text{ K}$
 Coefficient of linear expansion = $\alpha = 1.9 \times 10^{-5} \text{ K}^{-1}$
 Final length = $L = ?$
 Now

$$\begin{aligned} L &= L_0(1 + \alpha\Delta T) \\ &= 1(1 + 1.9 \times 10^{-5} \times 30) \\ &= 1 + 57 \times 10^{-5} \\ &= 1 + 0.00057 \\ &= 1.00057 \text{ m} \end{aligned}$$

Example 8.7: Find the volume of a brass cube at 100 °C whose side is 10 cm at 0 °C. (Coefficient of linear thermal expansion of brass is $1.9 \times 10^{-5} \text{ K}^{-1}$)

Sol: Initial length = $L_0 = 10 \text{ cm} = \frac{10}{100} \text{ m} = 0.1 \text{ m}$
 Initial temperature = $T_0 = 0^\circ\text{C} = 0 + 273 = 273 \text{ K}$
 Final temperature = $T = 100^\circ\text{C} = 100 + 273 = 373 \text{ K}$
 Change in temperature = $\Delta T = 373 - 273 = 100 \text{ K}$
 Coefficient of linear expansion = $\alpha = 1.9 \times 10^{-5} \text{ K}^{-1}$
 Final volume = $V = ?$
 Firstly:

$$\begin{aligned} \beta &= 3\alpha \\ &= 3 \times 1.9 \times 10^{-5} \\ &= 5.7 \times 10^{-5} \text{ K}^{-1} \end{aligned}$$

Secondly:

$$\begin{aligned} V_0 &= (L_0)^3 \\ &= (0.1)^3 \\ &= 0.001 \text{ m}^3 \\ &= 10^{-3} \text{ m}^3 \end{aligned}$$

Now

$$\begin{aligned} V &= V_0(1 + \beta\Delta T) \\ &= 10^{-3}(1 + 5.7 \times 10^{-5} \times 100) \\ &= 10^{-3}(1 + 5.7 \times 10^{-3}) \\ &= 10^{-3}(1 + 0.0057) \\ &= 10^{-3}(1.0057) \\ &= 1.0057 \times 10^{-3} \text{ m}^3 \end{aligned}$$

PROBLEMS

Problem 8.1: Temperature of water in a beaker is 50 °C. What is its value in Fahrenheit scale?

Sol: Temperature on Celsius scale = $T_C = 50^\circ\text{C}$
 Temperature on Fahrenheit scale = $T_F = ?$
 Now

$$\begin{aligned} T_F &= 1.8T_C + 32 \\ &= 1.8(50) + 32 \\ &= 90 + 32 \\ T_F &= 122^\circ\text{F} \end{aligned}$$

جسے خدا ذلیل کرنا چاہے وہ دولت کی تلاش میں لگ جاتا ہے۔ (حضرت حسن بصریؒ)

Problem 8.2: Normal human body temperature is 98.6 °F. Convert it into Celsius scale and Kelvin scale.

Sol: Temperature on Fahrenheit scale = $T_F = 98.6\text{ }^{\circ}\text{F}$
Temperature on Celsius scale = $T_C = ?$
Temperature on Kelvin scale = $T_K = ?$
Firstly:

$$\begin{aligned} T_C &= \frac{1}{1.8} (T_F - 32) \\ &= \frac{1}{1.8} (98.6 - 32) \\ &= \frac{1}{1.8} (66.6) \\ T_C &= 37\text{ }^{\circ}\text{C} \end{aligned}$$

Secondly:

$$\begin{aligned} T_K &= T_C + 273 \\ &= 37 + 273 \\ T_K &= 310\text{ K} \end{aligned}$$

Problem 8.3: Calculate the increase in the length of an aluminum bar 2 m long when heated from 0 °C to 20 °C. If the thermal coefficient of linear expansion of aluminum is $2.5 \times 10^{-5}\text{ K}^{-1}$.

Sol: Initial length = $L_o = 2\text{ m}$
Initial temperature = $T_o = 0\text{ }^{\circ}\text{C} = 0 + 273 = 273\text{ K}$
Final temperature = $T = 20\text{ }^{\circ}\text{C} = 20 + 273 = 293\text{ K}$
Change in temperature = $\Delta T = 293 - 273 = 20\text{ K}$
Coefficient of linear expansion = $\alpha = 2.5 \times 10^{-5}\text{ K}^{-1}$
Increase in length = $\Delta L = ?$
Firstly:

$$\begin{aligned} L &= L_o(1 + \alpha\Delta T) \\ &= 2 (1 + 2.5 \times 10^{-5} \times 20) \\ &= 2 (1 + 50 \times 10^{-5}) \\ &= 2 (1 + 0.0005) \\ &= 2 (1.0005) \\ L &= 2.001\text{ m} \end{aligned}$$

$$\begin{aligned} \text{Increase in length} = \Delta L &= L - L_o \\ &= 2.001 - 2 \\ &= 0.001\text{ m} \\ &= 0.001 \times 100\text{ cm} \\ &= 0.1\text{ cm} \end{aligned}$$

Problem 8.4: A balloon contains 1.2 m^3 air at $15\text{ }^{\circ}\text{C}$. Find the volume at $40\text{ }^{\circ}\text{C}$. Thermal coefficient of volume expansion of air is $3.67 \times 10^{-3}\text{ K}^{-1}$.

Sol: Initial volume = $V_o = 1.2\text{ m}^3$
Initial temperature = $T_o = 15\text{ }^{\circ}\text{C} = 15 + 273 = 288\text{ K}$
Final temperature = $T = 40\text{ }^{\circ}\text{C} = 40 + 273 = 313\text{ K}$
Change in temperature = $\Delta T = 313 - 288 = 25\text{ K}$
Coefficient of volume expansion = $\beta = 3.67 \times 10^{-3}\text{ K}^{-1}$
Final volume = $V = ?$
Now $V = V_o(1 + \beta\Delta T)$
 $= 1.2 (1 + 3.67 \times 10^{-3} \times 25)$
 $= 1.2 (1 + 91.75 \times 10^{-3})$
 $= 1.2 (1 + 0.09175)$

کسی سوال کا جواب اگر معلوم نہ ہو تو غلط جواب دینے سے بہتر ہے خاموش رہو۔ (حضرت ابن عربیؒ)

$$= 1.2 (1.09175)$$

$$= 1.3 \text{ m}^3$$

Problem 8.5: How much heat is required to increase the temperature of 0.5 kg of water from 10 °C to 65 °C?

Sol:

Mass of water	= m = 0.5 kg
Specific heat of water	= c = 4200 Jkg ⁻¹ K ⁻¹
Initial temperature	= T ₁ = 10 °C = 10 + 273 = 283 K
Final temperature	= T ₂ = 65 °C = 65 + 273 = 338 K
Change in temperature	= ΔT = 338 – 283 = 55 K
Amount of heat	= ΔQ = ?

Now

$$\Delta Q = mc\Delta T$$

$$= 0.5 \times 4200 \times 55$$

$$= 115500 \text{ J}$$

Problem 8.6: An electric heater supplies heat at the rate of 1000 joule per second. How much time is required to raise the temperature of 200 g of water from 20 °C to 90 °C?

Sol:

Rate of heat	= $\frac{\Delta Q}{t} = 1000 \text{ Js}^{-1}$
Mass	= m = 200 g = $\frac{200}{1000} = 0.2 \text{ kg}$
Specific heat of water	= c = 4200 Jkg ⁻¹ K ⁻¹
Initial temperature	= T ₁ = 20 °C = 20 + 273 = 293 K
Final temperature	= T ₂ = 90 °C = 90 + 273 = 363 K
Change in temperature	= ΔT = 363 – 293 = 70 K
Time	= t = ?

As

$$\Delta Q = mc\Delta T$$

Dividing both sides by t

$$\frac{\Delta Q}{t} = \frac{mc\Delta T}{t}$$

$$1000 = \frac{(0.2)(4200)(70)}{t}$$

$$t = \frac{(0.2)(4200)(70)}{1000}$$

$$= 58.8 \text{ sec}$$

Problem 8.7: How much ice will melt by 50000 J of heat? Latent heat of fusion of ice is 336000 Jkg⁻¹.

Sol:

Amount of heat	= ΔQ _f = 50000 J
Latent heat of fusion	= H _f = 336000 Jkg ⁻¹
Mass of ice	= m = ?

Now

$$\Delta Q_f = mH_f$$

$$m = \frac{\Delta Q_f}{H_f}$$

$$= \frac{50000}{336000}$$

$$= 0.149 \text{ kg}$$

$$= 0.149 \times 1000 \text{ g}$$

$$= 149 \text{ g}$$

Problem 8.8: Find the quantity of heat needed to melt 100 g of ice at $-10\text{ }^{\circ}\text{C}$ into water at $10\text{ }^{\circ}\text{C}$. (Note: specific heat of ice is $2100\text{ Jkg}^{-1}\text{K}^{-1}$, specific heat of water is $4200\text{ Jkg}^{-1}\text{K}^{-1}$, latent heat of fusion of ice is 336000 Jkg^{-1}).

Sol:

Mass of ice	= m	= 100 g = $\frac{100}{1000}$	= 0.1 kg
Initial temperature	= T_1	= $-10\text{ }^{\circ}\text{C}$ = $-10 + 273$	= 263 K
Final temperature	= T_2	= $10\text{ }^{\circ}\text{C}$ = $10 + 273$	= 283 K
Specific heat of ice	= c_1	= $2100\text{ Jkg}^{-1}\text{K}^{-1}$	
Specific heat of water	= c_2	= $4200\text{ Jkg}^{-1}\text{K}^{-1}$	
Latent heat of fusion of ice	= H_f	= 336000 Jkg^{-1}	
Quantity of heat	= ΔQ	= ?	

Firstly:
Amount of heat supplied to ice to increase temperature from $-10\text{ }^{\circ}\text{C}$ to $0\text{ }^{\circ}\text{C}$ is given by

Initial temperature	= T_1	= $-10\text{ }^{\circ}\text{C}$ = $-10 + 273$	= 263 K
Final temperature	= T_2	= $0\text{ }^{\circ}\text{C}$ = $0 + 273$	= 273 K
Change in temperature	= ΔT	= $273 - 263$	= 10 K

$$\Delta Q_1 = mc_1\Delta T$$
$$= 0.1 \times 2100 \times 10$$
$$= 2100\text{ J}$$

Secondly:
Amount of heat supplied to ice at $0\text{ }^{\circ}\text{C}$ to convert it into water is given by

$$\Delta Q_2 = mH_f$$
$$= 0.1 \times 336000$$
$$= 33600\text{ J}$$

Thirdly:
Amount of heat supplied to water to increase temperature from $0\text{ }^{\circ}\text{C}$ to $10\text{ }^{\circ}\text{C}$ is given by

Initial temperature	= T_2	= $0\text{ }^{\circ}\text{C}$ = $0 + 273$	= 273 K
Final temperature	= T_3	= $10\text{ }^{\circ}\text{C}$ = $10 + 273$	= 283 K
Change in temperature	= ΔT	= $283 - 273$	= 10 K

$$\Delta Q_3 = mc_2\Delta T$$
$$= 0.1 \times 4200 \times 10$$
$$= 4200\text{ J}$$

Lastly:
So total heat supplied to ice at $-10\text{ }^{\circ}\text{C}$ to raise its temperature to $10\text{ }^{\circ}\text{C}$ is

$$\Delta Q = \Delta Q_1 + \Delta Q_2 + \Delta Q_3$$
$$= 2100 + 33600 + 4200$$
$$= 39900\text{ J}$$

Problem 8.9: How much heat is required to change 100 g of water at $100\text{ }^{\circ}\text{C}$ into steam? (latent heat of vaporization is $2.26 \times 10^6\text{ Jkg}^{-1}$).

Sol:

Mass of water	= m	= 100 g = $\frac{100}{1000}$	= 0.1 kg
Latent heat of vaporization	= H_v	= $2.26 \times 10^6\text{ Jkg}^{-1}$	
Amount of heat	= ΔQ_v	= ?	

Now

$$\Delta Q_v = mH_v$$
$$= 0.1 \times 2.26 \times 10^6$$
$$= 0.226 \times 10^6$$
$$\Delta Q_v = 2.26 \times 10^5\text{ J}$$

Problem 8.10: Find the temperature of water after passing 5 g of steam at $100\text{ }^{\circ}\text{C}$ through 500 g of water at $10\text{ }^{\circ}\text{C}$.

اگر انسان ہوش مند ہو تو بے جا خواہشات سر نہیں اٹھائیں۔ (حضرت احمد خضر دہلویؒ)

(Note: specific heat of water is $4200 \text{ Jkg}^{-1}\text{K}^{-1}$, latent heat of vaporization is $2.26 \times 10^6 \text{ Jkg}^{-1}$).

Sol: Mass of steam = $m_1 = 5 \text{ g} = \frac{5}{1000} = 0.005 \text{ kg}$
 Temperature of steam = $T_1 = 100^\circ\text{C} = 100 + 273 = 373 \text{ K}$
 Mass of water = $m_2 = 500 \text{ g} = \frac{500}{1000} = 0.5 \text{ kg}$
 Temperature of water = $T_2 = 10^\circ\text{C} = 10 + 273 = 283 \text{ K}$
 Specific heat of water = $c = 4200 \text{ Jkg}^{-1}\text{K}^{-1}$
 Latent heat of vaporization of water = $H_v = 2.26 \times 10^6 \text{ Jkg}^{-1}$
 Temperature of water after passing the steam through it = $T_3 = ?$

Firstly:

Latent heat lost by steam is

$$\begin{aligned}\Delta Q_1 &= m_1 H_v \\ &= 0.005 \times 2.26 \times 10^6 \\ &= 0.0113 \times 10^6 \\ \Delta Q_1 &= 11300 \text{ J}\end{aligned}$$

Secondly:

Heat lost by steam to attain final temperature is

$$\begin{aligned}\Delta Q_2 &= m_1 c \Delta T \\ &= 0.005 \times 4200 \times (373 - T_3) \\ &= 21 \times (373 - T_3)\end{aligned}$$

Thirdly:

Heat gained by water is

$$\begin{aligned}\Delta Q_3 &= m_2 c \Delta T \\ &= 0.5 \times 4200 \times (T_3 - 283) \\ &= 2100 \times (T_3 - 283)\end{aligned}$$

Lastly:

$$\begin{aligned}\text{Heat lost by steam} &= \text{heat gained by water} \\ \Delta Q_1 + \Delta Q_2 &= \Delta Q_3 \\ 11300 + 21 \times (373 - T_3) &= 2100 \times (T_3 - 283) \\ 11300 + 7833 - 21T_3 &= 2100 T_3 - 594300 \\ 11300 + 7833 + 594300 &= 2100 T_3 + 21T_3 \\ 613433 &= 2121 T_3 \\ T_3 &= \frac{613433}{2121} \\ &= 289.2 \text{ K} \\ &= 289.2 - 273 \\ &= 16.2^\circ\text{C}\end{aligned}$$

بچہ اس بوتل کی مانند ہے جس کا منہ تنگ ہے۔ اگر اس بوتل میں جلدی سے پانی بھرنا چاہو تو ذرا سا پانی اس کے اندر چلا جائے گا اور بہت سا گر کر خراب ہو جائے گا لیکن اگر بوتل آہستہ آہستہ پانی سے بھرتے جائیں تو وہ آسانی سے بھر جائے گی۔ اسی طرح بچوں کو تھوڑا تھوڑا پڑھانا چاہیے یعنی جس قدر وہ یاد کر سکیں اس طرح ایک دن وہ بڑے عالم بن جائیں گے۔ (حکیم افلاطون)

(سٹی اکیڈمی سرگودھا)

پوزیشن ہولڈر سٹوڈنٹس کا واحد انتخاب

9th & 10th

ہو نہار طلباء طالبات میٹھ، فزکس، کیمسٹری، بیالوجی، کمپیوٹر، انگلش کورس کی اپنے سکول سے پہلے تکمیل کے لیے ہمارا انتخاب کرتے ہیں۔ کورس کی تکمیل کے بعد بورڈ کی نئی سکیم کے مطابق تیار کردہ ٹیسٹ کی مدد سے کورس کی دہرائی۔ ان ٹیسٹ سے گزرنے والا سٹوڈنٹ بورڈ کے امتحان میں یقینی %90 پلس مارکس حاصل کر سکتا ہے۔

(خوشخبری)

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